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The fate of microplastics when making sludge into crude oil – the impact of a hydrothermal liquefaction process on microplastics in wastewater treatment plant sludge

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Abstract

Microplastics (MPs) are entering wastewater treatment plants (WWTPs) from various sources such as primary MPs in consumer products and secondary MPs from wear of plastic items and textiles. There is a scientific consensus that the efficiency of WWTPs in retaining MPs is high, with up to 99% being retained and ultimately ending up in the sludge. Within a totally different research diciplin, scientist are also working on producing bio-crude oil from the sludge by processing it at pressures around 30 Mpa and temperatures around 400°C known as hydrothermal liquefaction (HTL). In an interdisciplinary study, we have studied the fate of MPs in WWTP sludge fed into a continuous HTL reactor. The HTL products as a mixture of bio-crude, aqueous, and solid residues have been investigated. Duplicate samples of each matrix were analyzed for MP. Wet-oxidation (H₂O₂), sodium dodecyl sulfate, and enzymatic treatment were performed to remove natural organic materials such as cellulose, protein, and lipid compounds. Inorganic particles were removed by density separation using sodium polytungstate solution. The bigger particles (> 500 µm) were separated by sieving and potential MP candidates handpicked and analyzed by ATR-FTIR (Agilent Cary 630, diamond ATR). The smaller particles (10-500 µm) were analyzed by FPA-µFTIR (Agilent Cary 620/670) and the particles identified using the software siMPle for automated analysis of the generated spectral image. 13 polymer types, comprising particles of 11-3207 µm, were observed in the sludge with Polyurethane (PU), Polyethylene (PE), Polypropylene (PP), Polyester (PEsT), alkyd, and cellulose acetate as the dominant ones. In the HTL products, only a few olefins such as PP and PE with sizes of 13.3-81.6 µm were observed. Furthermore, the MP removal efficiency of the HTL process was between 99.65% and 99.99% by particle numbers and mass respectively.

Keywords: Primary MPs, secondary MPs, hydrothermal liquefaction, sludge, bio-crude, aqueous and solid residue

